DRAFT

FINAL REPORT

NEED FOR PROCESS SPECIFICATION ON RADIOGRAPHY

SUBTASK B.4.3.15.10
CONTRACT NASw-410

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Task B.4.3.15 - Quality Standards, Procedures, and Guidelines

Subtask B.4.3.15.10 - Process Specification on Radiography

I. Summary

February 27, 1965

At the inception of this task it was persistently reported that a new and better specification for radiographic inspection was needed for Apollo components.

We found many areas of Apollo which were actually specifying and operating under very weak and vague radiographic specifications. This might seem to confirm the need for the new specification.

However, for the following reasons this is not the solution:

a. Radiographs are uniquely subject to a continuous quality check by means of recognized penetrameters.

b. There is available at least one excellent general purpose radiographic specification, MIL-STD-271C, if one is desired.

c. The tremendous multitude of available techniques plus the equally vast number of products and materials to be radiographed, each combination requiring its own procedure, make a general purpose specification nearly useless.

What is needed is the more rigid enforcement of Section 13 of NPC 200-2 calling for the Training and Certification of Personnel. This cry was heard everywhere across the country, with ever-increasing emphasis and insistence.

Certification procedures for nondestructive test personnel have been under development by the Society for Nondestructive Testing for three years and are complete for Radiographers. No other certification procedure was found to be as complete or thorough as this one. It's adoption is recommended.

A very few training courses are available, notably one at Louisiana State University, prepared under the direction of the Atomic Energy Commission, and another prepared by Bethel R. Johnson, MSC-FO, Cape Kennedy, Florida.

In view of all the above, we propose to discontinue this task of trying to develop a new "NASA Specification for Radiography."

An effective training and certification program coupled with formal approval of detailed procedures, will assure a maximum Quality in NASA radiographic inspections.

II. Extent of Survey

Information for the survey of industrial radiographic practices and procedures was obtained from many sources. A literature search was made by our library. Text books, radiographic standards, and technical journals were reviewed. The American Society of Tool and Manufacturing Engineers and the Society for Nondestructive Testing supplied information. Discussions were held with suppliers of radiographic equipment and several radiographic laboratories. Visits were made to Center and contractor facilities. In addition, several government, Center, and contractor specifications have been reviewed, analyzed, and compared.

A bibliography has been included that gives complete details on these sources of information.

III. Specifications

Confusion sometimes exists between the meaning of standard and specification. For our discussion of radiography, a standard is the authorized quality of a material to which other items are compared for acceptance or rejection. A specification is the imposed procedures for making acceptable radiographs.

More than two dozen radiographic specifications have been reviewed, nearly half have been or are being applied to Apollo, and most were inadequate. The glaring shortcoming is their incompleteness. Most describe a plan applicable to a certain facility, or a type of product such as castings or weldments. While nearly all call for the use of penetrameters, a device which measures the quality of a radiograph, most ignore techniques and the most important person of all -- the radiographic reader, or interpreter. A few specifications, primarily those issued by the Navy and the Atomic

Energy Commission for submarines and nuclear reactors, adequately describe the radiographic techniques that must be employed for specific projects and suggest qualifications that radiographic personnel should have. We found only one contractor who had a certification program and that applied only to radiographic readers. Personnel qualifications will be discussed further in Section V.

Issuance of a universal specification for all of Apollo is not felt advisable, however. With a wide range of products, from honeycomb structures in the spacecraft, to exotic castings, to subminiature electronic components, to tank welds in the booster, control can be better maintained by approval of formal procedures by the appropriate inspection agency. There are a multitude of materials and techniques, and with this approach, procedures can relate to the practices and details essential for each product.

IV. New Radiographic Techniques

The space age is ushering in extended use of thin, lightweight, high strength metals. Engineers, ever conscious of weight, generally allow a smaller safety factor than might be applied for normal ground applications. The ultimate soundness of the welded joints becomes critical, and in many locations, they are being radiographed 100%. Michoud reported that there are literally "miles of welds" in a booster. Lockheed actually calculated a little over one mile of welds on a Saturn booster. Radiography is a relatively slow process. Set-ups can take up to an hour or more, thick sections may require exposures that run into hours and even film processing may take nearly an hour. Considerable effort is being extended to automating portions of the radiographic cycle. Some of these innovations are listed below.

1. Lockheed has developed a TV-computer arrangement whereby a scanner "reads" the photographic density changes in the radiograph and reports to the computer. The computer has been programmed to analyze the density difference, or defects, and to print a list of those exceeding

specifications. The film reading time for 100 feet of film has been reduced from 7 1/2 hours to 40 minutes.

2. Electronic imaging systems provide a visual picture of X-ray exposures. An advantage is that these images can be enlarged while retaining fine resolution. This system also allows continuous observation of moving parts, or for the X-ray machine to move. There are tremendous in-process control advantages that could be developed from this system. One development experiment on automatically welding a high strength aluminum alloy actually showed the metal being transferred, the action of gas porosity in the molten metal as it penetrated to the root of the weld, the formation of cracks in the solidified weld metal and even their disappearance.

3. All radiographic interpretation is done by viewing various shades of black and gray. Physiologists, however, have proven that the eye is more sensitive to color than to brightness changes. The Argonne National Laboratory has produced colored radiographs, made up of shades of 3 colors. The system is still too elaborate for practical use at the present time.

4. New applications for radiography are continually being developed in many fields such as medicine and food, as well as industry. A unique application in industry is the examination of electronic components by radiography. A broken resistor wire, or a broken diode lead are readily visible to X-rays. It is known, however, that excessive radiation can change the molecular structure of materials. This is why materials used in space, electrical insulation for example, must be able to withstand radioactive bombardment. Investigation confirmed,

however, that the radioactive intensities and exposure times are far too small to damage even delicate electronic components. For semiconductor work a new measure of radiographic quality was needed; accordingly, an excellent, new penetrameter was developed by Lockheed and Texas Instruments which has now been adopted by ASTM.

These new techniques and procedures emphasize the paramount need of the entire program to utilize specially trained and certified personnel.

V. Proposal by the Society for Nondestructive Testing

Little attention has been given in the past to qualifications of radiographic personnel and equipment capabilities. Various government agencies have issued certifications based on the results from radiographing "test blocks." The blocks were fairly simple and merely proved that one person in the laboratory understood simple radiographic techniques. Three factors make this method of certification inadequate for Apollo. They are:

1. A wide range of radiographic techniques are applicable to Apollo because of the wide range of materials and complexity of parts.
2. Nondestructive Testing is a rapidly growing field and many new people are entering, many with limited experience and knowledge of nondestructive testing.
3. The value of even a perfect radiograph is lost if the reader does not have the training and experience to "read" the shadows of the radiograph and properly compare it to the established standards.

The need for certification of radiographic facilities and personnel has been unanimously recognized by contractors, AEC, and GIA's. Training courses have been developed at Louisiana State and Ohio State Universities. A training course has been developed for a new facility at KSC, and a very few contractors have developed their own training programs. The most complete program for certifying equipment and personnel, including a program to train those not completely qualified, is one proposed by the National Society for Nondestructive Testing.

The Society's proposal is designed from the management view, to enable management to establish the level of capability desired, and to qualify personnel to that level by actually measuring their qualifications. There are many advantages to this proposal:

1. The responsibility for evaluating the capability of the radiographic personnel and facilities can remain within the facilities' own management and need not be exercised by an outside agency such as the Air Force or Navy.

   Conversely, NASA could use the SNT proposed standards to evaluate a prime contractor and they in turn could evaluate their subcontractors.
2. Evaluations of a laboratory could be made to the specific skills applicable to Apollo.
3. The chances of unknowledgeable people holding jobs requiring radiographic skills will be minimized.
4. New radiographic techniques could be introduced under component control with little danger of loss in quality.
5. Revisions and maintenance of the Society's proposal is their responsibility.

This proposal has been under development the past few years by some of the most noted radiographic authorities in the nation.

VI. Conclusion

There are an adequate number of standards to which a designer can refer to assure the integrity of his design.

Since radiography is a test or inspection method and not a product, issuance of a universal specification is not recommended. Specific and detailed procedures should be prepared for each application and approved by the responsible inspection agency of each Center.

The most significant problem in radiography today is assurance that personnel are qualified to use the new techniques and capable of interpreting the results correctly. It is suggested that MAR encourage the adoption of the Society for Nondestructive Testing's proposal

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